

1-ALKYL-3-THIO-SUBSTITUTED INDOLE-2-ALKYNOIC ACIDS USEFUL FOR THE TREATMENT FOR ALZHEIMER'S DISEASE AND RELATED CONDITIONS

This invention relates to the use of methods and materials for use in
5 therapeutic treatment of the human body. In particular, it provides methods of treating diseases associated with the deposition of β -amyloid peptide in the brain, such as Alzheimer's disease, or of preventing or delaying the onset of dementia associated with such diseases.

Alzheimer's disease (AD) is the most prevalent form of dementia. Its
10 diagnosis is described in the Diagnostic and Statistical Manual of Mental Disorders, 4th ed., published by the American Psychiatric Association (DSM-IV). It is a neurodegenerative disorder, clinically characterized by progressive loss of memory and general cognitive function, and pathologically characterized by the deposition of extracellular proteinaceous plaques in the cortical and associative brain regions of
15 sufferers. These plaques mainly comprise fibrillar aggregates of β -amyloid peptide ($A\beta$). $A\beta$ is formed from amyloid precursor protein (APP) via separate intracellular proteolytic events involving the enzymes β -secretase and γ -secretase. Variability in the site of the proteolysis mediated by γ -secretase results in $A\beta$ of varying chain length, e.g. $A\beta(1-38)$, $A\beta(1-40)$ and $A\beta(1-42)$. N-terminal truncations such as $A\beta(4-20$
20 42) are also found in the brain, possibly as a result of variability in the site of proteolysis mediated by β -secretase. For the sake of convenience, expressions such as " $A\beta(1-40)$ " and " $A\beta(1-42)$ " as used herein are inclusive of such N-terminal truncated variants. After secretion into the extracellular medium, $A\beta$ forms initially-soluble aggregates which are widely believed to be the key neurotoxic agents in AD (see Gong
25 *et al*, *PNAS*, **100** (2003), 10417-22), and which ultimately result in the insoluble deposits and dense neuritic plaques which are the pathological characteristics of AD.

Other dementing conditions associated with deposition of $A\beta$ in the brain include cerebral amyloid angiopathy, hereditary cerebral haemorrhage with amyloidosis, Dutch-type (HCHWA-D), multi-infarct dementia, dementia pugilistica
30 and Down syndrome.

Various interventions in the plaque-forming process have been proposed as therapeutic treatments for AD (see, for example, Hardy and Selkoe, *Science*, **297** (2002), 353-6). One such method of treatment that has been proposed is that of blocking or attenuating the production of A β , for example by inhibition of β - or γ -secretase. It has also been reported that inhibition of glycogen synthase kinase-3 (GSK-3), in particular inhibition of GSK-3 α , can block the production of A β (see Phiel et al, *Nature*, **423** (2003), 435-9).

Other proposed methods of treatment include administering a compound which blocks the aggregation of A β , and administering an antibody which selectively binds to A β .

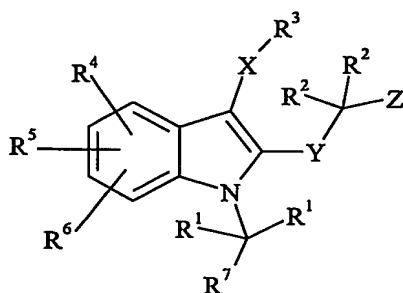
Another proposed treatment is that of modulation of the action of γ -secretase so as to selectively attenuate the production of A β (1-42). This results in preferential secretion of the shorter chain isoforms of A β , which are believed to have a reduced propensity for self-aggregation and plaque formation, and hence are more easily cleared from the brain, and/or are less neurotoxic. Compounds showing this effect include certain non-steroidal antiinflammatory drugs (NSAIDs) and their analogues (see WO 01/78721 and US 2002/0128319 and Weggen et al *Nature*, **414** (2001) 212-16; Morihara et al, *J. Neurochem.*, **83** (2002), 1009-12; and Takahashi et al, *J. Biol. Chem.*, **278** (2003), 18644-70). Certain compounds which modulate the activity of PPAR α and/or PPAR δ are also reported to have the effect of lowering A β (1-42) (WO 02/100836). NSAID derivatives capable of releasing nitric oxide have been reported to show improved anti-neuroinflammatory effects and/or to reduce intracerebral A β deposition in animal models (WO 02/092072; Jantzen et al, *J. Neuroscience*, **22** (2002), 226-54). US 2002/0015941 teaches that agents which potentiate capacitative calcium entry activity can lower A β (1-42).

US 5,081,138 discloses a broad class of 1-benzyl-3-thio-substituted indole-2-alkanoic acids as inhibitors of leukotriene biosynthesis, useful in treatment of asthma, allergies, inflammation, diarrhoea, hypertension, angina, platelet aggregation, cerebral spasm, premature labour, spontaneous abortion, dysmenorrhea and migraine. There is no disclosure or suggestion of any effect on the secretion of A β , or of any utility in the

treatment or prevention of AD or any other disorders associated with deposition of A β in the brain.

It has now been found that certain 1-alkyl-3-thio-substituted indole-2-alkanoic acids have the desirable property of selectively inhibiting production of A β (1-42).

- 5 According to the present invention there is provided a method of treating or preventing a disease associated with deposition of A β in the brain comprising administering to a patient in need thereof a therapeutically effective amount of a compound of Formula I



(I)

- 10 wherein each R¹ is independently H, C₁₋₆alkyl or C₃₋₆cycloalkyl;
 each R² is independently H or C₁₋₆alkyl, or the two R² groups together complete a C₃₋₆cycloalkyl group;
 R³ represents a hydrocarbon group of up to 10 carbon atoms optionally bearing up to 2 substituents selected from halogen, CN, CF₃, OCF₃, C₁₋₄alkoxy, C₁₋₄alkylthio, CO₂H, C₁₋₄alkoxycarbonyl, C₁₋₄alkylcarbonyl and C₁₋₄alkylcarbonyloxy; or R³
 15 represents a heteroaryl group of 5 or 6 ring atoms which is optionally benzo-fused, optionally bearing up to 2 substituents selected from C₁₋₄alkyl, halogen, CN, CF₃, OCF₃, C₁₋₄alkoxy, C₁₋₄alkylthio, CO₂H, C₁₋₄alkoxycarbonyl, C₁₋₄alkylcarbonyl and C₁₋₄alkylcarbonyloxy;
 20 R⁴, R⁵ and R⁶ independently represent H, halogen, CN, CF₃, OCF₃, C₁₋₄alkoxy, C₁₋₄alkylthio, CO₂H, C₁₋₄alkoxycarbonyl, C₁₋₄alkylcarbonyl, C₁₋₄alkylcarbonyloxy or hydrocarbon of up to 7 carbon atoms optionally bearing a substituent selected from halogen, CN, CF₃, OCF₃, C₁₋₄alkoxy, C₁₋₄alkylthio, CO₂H, C₁₋₄alkoxycarbonyl, C₁₋₄alkylcarbonyl and C₁₋₄alkylcarbonyloxy;

R^7 represents a hydrocarbon group of up to 10 carbon atoms optionally bearing up to 2 substituents selected from halogen, CN, CF_3 , OCF_3 , C_{1-4} alkoxy, C_{1-4} alkylthio, CO_2H , C_{1-4} alkoxycarbonyl, C_{1-4} alkylcarbonyl and C_{1-4} alkylcarbonyloxy;

X represents O or S;

5 Y represents a bond, CH_2 , CH_2CH_2 , $CH_2CH_2CH_2$ or CH_2CH_2O ; and

Z represents CO_2H or tetrazol-5-yl;

or a pharmaceutically acceptable salt thereof.

The disease associated with deposition of $A\beta$ in the brain is typically Alzheimer's disease (AD), cerebral amyloid angiopathy, HCHWA-D, multi-infarct
10 dementia, dementia pugilistica or Down syndrome, in particular AD.

In a second aspect, the invention provides a method of treating, preventing or delaying the onset of dementia associated with Alzheimer's disease, cerebral amyloid angiopathy, HCHWA-D, multi-infarct dementia, dementia pugilistica or Down syndrome comprising administering to a patient in need thereof a therapeutically
15 effective amount of a compound of Formula I as defined above or a pharmaceutically acceptable salt thereof.

The invention also provides the use, for the manufacture of a medicament for treatment or prevention of a disease associated with the deposition of β -amyloid in the brain, of a compound of formula I as defined above.

20 In a further aspect, the invention provides the use of a compound of Formula I as defined above, or a pharmaceutically acceptable salt thereof, in the manufacture of a medicament for treating, preventing or delaying the onset of dementia associated with Alzheimer's disease, cerebral amyloid angiopathy, HCHWA-D, multi-infarct dementia, dementia pugilistica or Down syndrome.

25 The compounds of Formula I modulate the action of γ -secretase so as to selectively attenuate production of the (1-42) isoform of $A\beta$ without significantly lowering production of the shorter chain isoforms such as $A\beta(1-40)$. This results in secretion of $A\beta$ which has less tendency to self-aggregate and form insoluble deposits, is more easily cleared from the brain, and/or is less neurotoxic. Therefore, a further
30 aspect of the invention provides a method for retarding, arresting or preventing the accumulation of $A\beta$ in the brain comprising administering to a subject in need thereof

a therapeutically effective amount of a compound of Formula I as defined above or a pharmaceutically acceptable salt thereof.

Because the compounds of formula I modulate the activity of γ -secretase, as opposed to suppressing said activity, it is believed that the therapeutic benefits described above will be obtained with a reduced risk of side effects, e.g. those that might arise from a disruption of other signalling pathways (e.g. Notch) which are controlled by γ -secretase.

In one embodiment of the invention, the compound of Formula I is administered to a patient suffering from AD, cerebral amyloid angiopathy, HCHWA-D, multi-infarct dementia, dementia pugilistica or Down syndrome, in particular a patient suffering from AD.

In an alternative embodiment of the invention, the compound of Formula I is administered to a patient suffering from mild cognitive impairment or age-related cognitive decline. A favourable outcome of such treatment is prevention or delay of the onset of AD. Age-related cognitive decline and mild cognitive impairment (MCI) are conditions in which a memory deficit is present, but other diagnostic criteria for dementia are absent (Santacruz and Swagerty, *American Family Physician*, **63** (2001), 703-13). (See also "The ICD-10 Classification of Mental and Behavioural Disorders", Geneva: World Health Organisation, 1992, 64-5). As used herein, "age-related cognitive decline" implies a decline of at least six months' duration in at least one of: memory and learning; attention and concentration; thinking; language; and visuospatial functioning and a score of more than one standard deviation below the norm on standardized neuropsychologic testing such as the MMSE. In particular, there may be a progressive decline in memory. In the more severe condition MCI, the degree of memory impairment is outside the range considered normal for the age of the patient but AD is not present. The differential diagnosis of MCI and mild AD is described by Petersen *et al.*, *Arch. Neurol.*, **56** (1999), 303-8. Further information on the differential diagnosis of MCI is provided by Knopman *et al*, *Mayo Clinic Proceedings*, **78** (2003), 1290-1308. In a study of elderly subjects, Tuokko *et al* (*Arch. Neurol.*, **60** (2003) 577-82) found that those exhibiting MCI at the outset had a three-fold increased risk of developing dementia within 5 years.

Grundman et al (*J. Mol. Neurosci.*, **19** (2002), 23-28) report that lower baseline hippocampal volume in MCI patients is a prognostic indicator for subsequent AD. Similarly, Andreasen et al (*Acta Neurol. Scand*, **107** (2003) 47-51) report that high CSF levels of total tau, high CSF levels of phospho-tau and lowered CSF levels of A β 42 are all associated with increased risk of progression from MCI to AD.

Within this embodiment, the compound of Formula I is advantageously administered to patients who suffer impaired memory function but do not exhibit symptoms of dementia. Such impairment of memory function typically is not attributable to systemic or cerebral disease, such as stroke or metabolic disorders caused by pituitary dysfunction. Such patients may be in particular people aged 55 or over, especially people aged 60 or over, and preferably people aged 65 or over. Such patients may have normal patterns and levels of growth hormone secretion for their age. However, such patients may possess one or more additional risk factors for developing Alzheimer's disease. Such factors include a family history of the disease; a genetic predisposition to the disease; elevated serum cholesterol; and adult-onset diabetes mellitus.

In a particular embodiment of the invention, the compound of Formula I is administered to a patient suffering from age-related cognitive decline or MCI who additionally possesses one or more risk factors for developing AD selected from: a family history of the disease; a genetic predisposition to the disease; elevated serum cholesterol; adult-onset diabetes mellitus; elevated baseline hippocampal volume; elevated CSF levels of total tau; elevated CSF levels of phospho-tau; and lowered CSF levels of A β (1-42).

A genetic predisposition (especially towards early onset AD) can arise from point mutations in one or more of a number of genes, including the APP, presenilin-1 and presenilin-2 genes. Also, subjects who are homozygous for the ϵ 4 isoform of the apolipoprotein E gene are at greater risk of developing AD.

The patient's degree of cognitive decline or impairment is advantageously assessed at regular intervals before, during and/or after a course of treatment in accordance with the invention, so that changes therein may be detected, e.g. the slowing or halting of cognitive decline. A variety of neuropsychological tests are known in the art for this purpose, such as the Mini-Mental State Examination

(MMSE) with norms adjusted for age and education (Folstein *et al.*, *J. Psych. Res.*, 12 (1975), 196-198, Anthony *et al.*, *Psychological Med.*, 12 (1982), 397-408; Cockrell *et al.*, *Psychopharmacology*, 24 (1988), 689-692; Crum *et al.*, *J. Am. Med. Assoc'n.* 18 (1993), 2386-2391). The MMSE is a brief, quantitative measure of
5 cognitive status in adults. It can be used to screen for cognitive decline or impairment, to estimate the severity of cognitive decline or impairment at a given point in time, to follow the course of cognitive changes in an individual over time, and to document an individual's response to treatment. Another suitable test is the Alzheimer Disease Assessment Scale (ADAS), in particular the cognitive element thereof (ADAS-cog)
10 (See Rosen *et al.*, *Am. J. Psychiatry*, 141 (1984), 1356-64).

Where a variable occurs more than once in formula I or in a substituent thereof, the individual occurrences of that variable are independent of each other, unless otherwise specified.

As used herein, the expression "hydrocarbon group" refers to groups consisting
15 solely of carbon and hydrogen atoms. Such groups may comprise linear, branched or cyclic structures, singly or in any combination consistent with the indicated maximum number of carbon atoms, and may be saturated or unsaturated, including aromatic when the indicated maximum number of carbon atoms so permits unless otherwise indicated.

As used herein, the expression "C_{1-x}alkyl" where x is an integer greater than 1
20 refers to straight-chained and branched alkyl groups wherein the number of constituent carbon atoms is in the range 1 to x. Particular alkyl groups are methyl, ethyl, n-propyl, isopropyl and t-butyl. Derived expressions such as "C₂₋₆alkenyl", "hydroxyC₁₋₆alkyl", "heteroarylC₁₋₆alkyl", "C₂₋₆alkynyl" and "C₁₋₆alkoxy" are to be construed in an
25 analogous manner. Most suitably, the number of carbon atoms in such groups is not more than 6.

The term "halogen" as used herein includes fluorine, chlorine, bromine and iodine, of which fluorine and chlorine are preferred.

The term "heteroaryl" as used herein refers to an aromatic ring in which one or
30 more of the ring atoms is other than carbon. Preferably, said one or more ring atoms are selected from N, O and S.

For use in medicine, the compounds of formula I may be in the form of pharmaceutically acceptable salts. Other salts may, however, be useful in the preparation of the compounds of formula I or of their pharmaceutically acceptable salts. Suitable pharmaceutically acceptable salts of the compounds of this invention

5 include acid addition salts which may, for example, be formed by mixing a solution of the compound according to the invention with a solution of a pharmaceutically acceptable acid such as hydrochloric acid, sulphuric acid, methanesulphonic acid, benzenesulphonic acid, fumaric acid, maleic acid, succinic acid, acetic acid, benzoic acid, oxalic acid, citric acid, tartaric acid, carbonic acid or phosphoric acid.

10 Alternatively, where the compound of the invention carries an acidic moiety, a pharmaceutically acceptable salt may be formed by neutralisation of said acidic moiety with a suitable base. Examples of pharmaceutically acceptable salts thus formed include alkali metal salts such as sodium or potassium salts; ammonium salts; alkaline earth metal salts such as calcium or magnesium salts; and salts formed with suitable

15 organic bases, such as amine salts (including pyridinium salts) and quaternary ammonium salts.

Where the compounds according to the invention have at least one asymmetric centre, they may accordingly exist as enantiomers. Where the compounds according to the invention possess two or more asymmetric centres, they may additionally exist

20 as diastereoisomers. It is to be understood that all such isomers and mixtures thereof in any proportion are encompassed within the scope of the present invention.

In formula I, X represents O or S. In a preferred embodiment, X represents S.

Y represents a bond, CH₂, CH₂CH₂, CH₂CH₂CH₂ or CH₂CH₂O. Typically, Y represents a bond, CH₂ or CH₂CH₂O, and preferably represents CH₂.

25 Z represents CO₂H or tetrazol-5-yl. Preferably, Z represents CO₂H.

In Formula I, each R¹ is independently H, C₁₋₆ alkyl or C₃₋₆ cycloalkyl. Examples include H, methyl, ethyl, propyl and cyclopropyl. Preferably at least one R¹ is H. In one preferred embodiment, both R¹ groups are H. In another preferred embodiment, one R¹ is H and the other is methyl, ethyl or propyl, preferably methyl.

30 Each R² is independently H or C₁₋₆alkyl (such as methyl or ethyl), or the two R² groups together complete a cycloalkane of 3-6 members (such as cyclopentane or

cyclohexane). Preferably, at least one R^2 is other than H, and most preferably neither R^2 is H. In a preferred embodiment both R^2 groups are methyl.

R^3 represents hydrocarbon of up to 10 carbon atoms, optionally substituted as defined previously, or heteroaryl of 5 to 6 atoms, optionally benzo-fused, optionally substituted as defined previously. Typical hydrocarbon groups include alkyl (especially branched alkyl, such as t-butyl), cycloalkyl (such as cyclohexyl), phenyl, phenyl-substituted alkyl (such as benzyl), and alkyl-substituted phenyl (such as tolyl or xylyl). Preferred substituents (where present) include halogen, especially Cl. Typical heteroaryl rings include pyridine, quinoline, isoquinoline, thiazole and benzothiazole, on which the preferred substituents (where present) include halogen, especially Cl.

In a preferred embodiment, R^3 is selected from alkyl, cycloalkyl, alkyl-substituted phenyl and chloro-substituted phenyl.

Specific examples of groups represented by R^3 include t-butyl, cyclohexyl, phenyl, 2,5-dimethylphenyl, 2,6-dimethylphenyl, 3,5-dimethylphenyl, 3,4-dimethylphenyl, 2,4-dimethylphenyl, 4-chlorophenyl, 3,4-dichlorophenyl and 5-chlorobenzothiazol-2-yl.

R^4 , R^5 and R^6 are perfectly selected from H, halogen, CN, CF_3 , OCF_3 , C_{1-4} alkoxy, C_{1-6} alkyl and optionally-substituted phenyl. Preferably, at least one of R^4 , R^5 and R^6 is other than H. When two or more of R^4 , R^5 and R^6 are other than H, they are very aptly selected from C_{1-6} alkyl and halogen. R^4 , R^5 and R^6 may occupy any of the available ring positions, but in one preferred embodiment, two of R^4 , R^5 and R^6 are H and the third is attached to the 5-position. Specific examples of groups represented by R^4 , R^5 and R^6 include H, methyl, isopropyl, Cl, Br, F, CF_3 , OCF_3 and phenyl.

Examples of hydrocarbon groups represented by R^7 include alkyl (e.g. of up to 6 carbon atoms, such as methyl, ethyl, propyl or butyl), which is optionally substituted as defined previously; alkenyl (e.g. of up to 6 carbon atoms, such as vinyl or allyl), cycloalkyl (e.g. of up to 6 carbon atoms, such as cyclohexyl), and optionally substituted phenyl. Phenyl groups represented by R^7 preferably bear at least one substituent, and preferably not more than two substituents. If more than two substituents are present, at least one of them must be C_{1-4} alkyl. When a single substituent is present, it is preferably (but not necessarily) in the 4-position. Examples

of preferred substituents include C₁₋₄alkyl (such as methyl, ethyl, propyl and butyl, especially t-butyl); halogen (especially Cl and F); CN; CF₃; OCF₃; CO₂H and C₁₋₄alkylthio (especially methylthio). Specific examples of groups represented by R⁷ include methyl, methoxymethyl, vinyl, cyclohexyl, phenyl, 4-chlorophenyl, 4-trifluoromethylphenyl, 4-fluorophenyl, 2,4-dichlorophenyl, 2,4-difluorophenyl, 4-trifluoromethoxyphenyl, 4-t-butylphenyl, 3,5-bis(trifluoromethyl)phenyl, 4-methylthiophenyl, 4-cyanophenyl, 3-trifluoromethylphenyl and 3-carboxyphenyl.

Specific examples suitable for use in the invention include the compounds of formula I in which X is S, Y is CH₂, Z is CO₂H, one R¹ group is H, both R² groups are Me (unless otherwise indicated), and the remaining variables are as shown in the following table:

Table 1

R ¹	R ³	R ⁴ ,R ⁵ ,R ⁶	R ⁷
Me	2,5-di-Me-Ph	5-isopropyl	4-Cl-Ph
H	2,5-di-Me-Ph	5-isopropyl	4-CF ₃ -Ph
Me	2,5-di-Me-Ph	5-isopropyl	Me
H	2,6-di-Me-Ph	5-isopropyl	4-CF ₃ -Ph
H	3,5-di-Me-Ph	5-isopropyl	4-CF ₃ -Ph
Me	2,5-di-Me-Ph	5-isopropyl	4-CF ₃ -Ph
H	2,5-di-Me-Ph	5-F	4-CF ₃ -Ph
H	3,4-di-Me-Ph	5-isopropyl	2,4-di-F-Ph
H	2,5-di-Me-Ph	5-Br	4-CF ₃ -Ph
H	2,5-di-Me-Ph	5-Br	4-Cl-Ph
H	2,5-di-Me-Ph	5-Cl	4-CF ₃ -Ph
H	2,5-di-Me-Ph	5-isopropyl	2,4-di-Cl-Ph
H	2,5-di-Me-Ph	5-OCF ₃	4-CF ₃ -Ph
H	2,5-di-Me-Ph	5-isopropyl	2,4-di-CF ₃ -Ph
H	3,5-di-Me-Ph	5-isopropyl	4-Cl-Ph
Et	2,5-di-Me-Ph	5-isopropyl	4-CF ₃ -Ph
H	2,5-di-Me-Ph	5-Cl	4-Cl-Ph

R^1	R^3	R^4, R^5, R^6	R^7
H	2,5-di-Me-Ph	5-isopropyl	cyclohexyl
H	2,5-di-Me-Ph	5-isopropyl	4-CF ₃ O-Ph
H	3,4-di-Me-Ph	5-isopropyl	4-CF ₃ -Ph
H	2,5-di-Me-Ph	5-CF ₃	4-CF ₃ -Ph
H	2,5-di-Me-Ph	5-isopropyl	2,4-di-F-Ph
H	2,5-di-Me-Ph	5-CF ₃ O	2,4-di-F-Ph
H	2,4-di-Me-Ph	5-isopropyl	4-CF ₃ -Ph
H	2,6-di-Me-Ph	5-isopropyl	4-Cl-Ph
H	2,5-di-Me-Ph	5-isopropyl	Ph
H	2,5-di-Me-Ph	5-t-butyl	4-CF ₃ -Ph
H	2,5-di-Me-Ph	5-F	4-Cl-Ph
cyclopropyl	2,5-di-Me-Ph	5-isopropyl	4-CF ₃ -Ph
H	2,5-di-Me-Ph	5-isopropyl	4-t-butyl-Ph
H	2,5-di-Me-Ph	5-isopropyl	3,5-di-CF ₃ -Ph
H	2,5-di-Me-Ph	5-isopropyl	4-Cl-Ph
H	2,5-di-Me-Ph	6,7-di-Me	4-CF ₃ -Ph
H	2,4-di-Me-Ph	5-isopropyl	4-Cl-Ph
H	cyclohexyl	5-isopropyl	4-Cl-Ph
H	2,5-di-Me-Ph	5-isopropyl	4-MeS-Ph
H	2,5-di-Me-Ph	6,7-di-Me	4-Cl-Ph
H	2,5-di-Cl-Ph	5-isopropyl	2,4-di-F-Ph
H	2,5-di-Cl-Ph	5-isopropyl	4-CF ₃ -Ph
H	2,5-di-Me-Ph	5,7-di-Me	4-Cl-Ph
H	2,5-di-Me-Ph	5-CF ₃ O	4-F-Ph
H	2,5-di-Me-Ph	5-isopropyl	vinyl
H	2,5-di-Me-Ph	5-Cl	4-CN-Ph
H	2,5-di-Me-Ph	5-CF ₃ O	3-Cl-Ph
H	2,5-di-Me-Ph	5-isopropyl	MeOCH ₂
H	2,5-di-Me-Ph	5-CF ₃ O	4-Cl-Ph
H	2,5-di-Me-Ph	5-isopropyl	3-CF ₃ -Ph

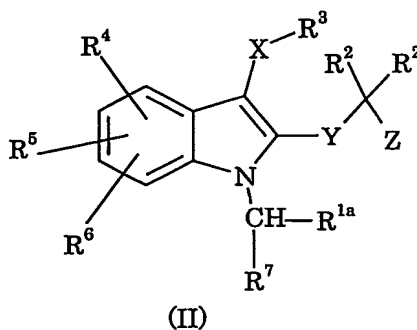
R^1	R^3	R^4, R^5, R^6	R^7
H	2,5-di-Me-Ph	5-F	4-CN-Ph
H	3,4-di-Cl-Ph	5-isopropyl	4-CF ₃ -Ph
H*	t-butyl	5-isopropyl	4-Cl-Ph
H	4-Cl-Ph	5-isopropyl	4-Cl-Ph
H	3,4-di-Me-Ph	5-isopropyl	4-Cl-Ph
H	3,4-di-Cl-Ph	5-isopropyl	4-Cl-Ph
H	t-butyl	5-Ph	4-Cl-Ph
H	2,5-di-Me-Ph	5-isopropyl	3-HOOC-Ph
H	t-butyl	5-isopropyl	4-Cl-Ph
H	5-Cl-benzothiazol-2-yl	5-isopropyl	4-Cl-Ph

* the two R^2 groups together complete a cyclopentyl ring.

Further specific compounds suitable for use in the invention include compounds of formula I in which each R^1 is H, R^4 is 5-isopropyl, R^5 and R^6 are H, R^7 is 4-chlorophenyl and the remaining variables are as shown in table 2:

R^2/R^2	R^3	X	Y	Z
H, H	t-butyl	S	bond	tetrazol-5-yl
H, H	t-butyl	S	CH ₂ CH ₂ O	CO ₂ H
H, methyl	t-butyl	S	CH ₂ CH ₂ O	CO ₂ H
methyl, methyl	sec-butyl	O	CH ₂	CO ₂ H

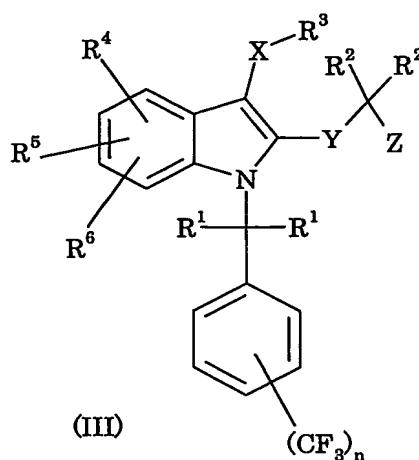
A first subset of the compounds of Formula I is defined by Formula II:



wherein R^{1a} represents C₁₋₆alkyl or C₃₋₆cycloalkyl, and R²-R⁷, X, Y and Z have the same definitions and preferred identities as before.

Compounds of Formula II and the pharmaceutically acceptable salts thereof are believed to be novel and hence constitute a further aspect of the invention. Preferably, X is S, Y is CH₂ and Z is CO₂H.

A second subset of the compounds of Formula I is defined by Formula III:



example, a racemic mixture may be resolved into its component enantiomers by preparative chiral HPLC, or by treatment with an optically pure amine to form diastereomeric salt pairs, separable by fractional crystallisation, from which the optically pure acids may be regenerated. Similarly, a racemic acid may be reacted with an optically pure alcohol or amine to form pairs of diastereomeric esters or amides which may be separated by chromatography or fractional crystallisation and hydrolysed to yield enantiomerically-pure acids. These resolution techniques may equally well be practised on the synthetic precursors of the compounds of Formulae I, II and III and the resulting optically-pure intermediates used to prepare compounds of Formulae I, II and III in optically-pure form.

The compounds of Formulae I, II and III are typically used in the form of pharmaceutical compositions comprising one or more compounds of Formula I, II or III and a pharmaceutically acceptable carrier. Preferably these compositions are in unit dosage forms such as tablets, pills, capsules, powders, granules, sterile parenteral solutions or suspensions, metered aerosol or liquid sprays, drops, ampoules, transdermal patches, auto-injector devices or suppositories; for oral, parenteral, intranasal, sublingual or rectal administration, or for administration by inhalation or insufflation. The principal active ingredient typically is mixed with a pharmaceutical carrier, e.g. conventional tableting ingredients such as corn starch, lactose, sucrose, sorbitol, talc, stearic acid, magnesium stearate and dicalcium phosphate, or gums, dispersing agents, suspending agents or surfactants such as sorbitan monooleate and polyethylene glycol, and other pharmaceutical diluents, e.g. water, to form a homogeneous preformulation composition containing a compound of the present invention, or a pharmaceutically acceptable salt thereof. When referring to these preformulation compositions as homogeneous, it is meant that the active ingredient is dispersed evenly throughout the composition so that the composition may be readily subdivided into equally effective unit dosage forms such as tablets, pills and capsules. This preformulation composition is then subdivided into unit dosage forms of the type described above containing from 0.1 to about 500 mg of the active ingredient of the present invention. Typical unit dosage forms contain from 1 to 100 mg, for example 1, 2, 5, 10, 25, 50 or 100 mg, of the active ingredient. Tablets or pills of the composition can be coated or otherwise compounded to provide a dosage form

affording the advantage of prolonged action. For example, the tablet or pill can comprise an inner dosage and an outer dosage component, the latter being in the form of an envelope over the former. The two components can be separated by an enteric layer which serves to resist disintegration in the stomach and permits the inner
5 component to pass intact into the duodenum or to be delayed in release. A variety of materials can be used for such enteric layers or coatings, such materials including a number of polymeric acids and mixtures of polymeric acids with such materials as shellac, cetyl alcohol and cellulose acetate.

The liquid forms in which the compositions useful in the present invention
10 may be incorporated for administration orally or by injection include aqueous solutions, liquid- or gel-filled capsules, suitably flavoured syrups, aqueous or oil suspensions, and flavoured emulsions with edible oils such as cottonseed oil, sesame oil, coconut oil or peanut oil, as well as elixirs and similar pharmaceutical vehicles. Suitable dispersing or suspending agents for aqueous suspensions include synthetic
15 and natural gums such as tragacanth, acacia, alginate, dextran, sodium carboxymethylcellulose, methylcellulose, poly(ethylene glycol), poly(vinylpyrrolidone) or gelatin.

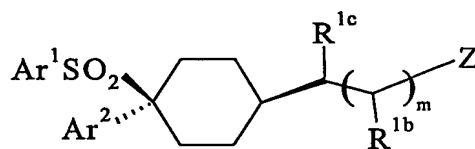
For treating or preventing Alzheimer's disease, a suitable dosage level is about 0.01 to 250 mg/kg per day, preferably about 0.01 to 100 mg/kg per day, and more
20 preferably about 0.05 to 50 mg/kg of body weight per day, of the active compound. The compounds may be administered on a regimen of 1 to 4 times per day. In some cases, however, a dosage outside these limits may be used.

The compounds of Formula I optionally may be administered in combination with one or more additional compounds known to be useful in the treatment or
25 prevention of AD or the symptoms thereof. Such additional compounds thus include cognition-enhancing drugs such as acetylcholinesterase inhibitors (e.g. donepezil and galanthamine), NMDA antagonists (e.g. memantine) or PDE4 inhibitors (e.g. Ariflo™ and the classes of compounds disclosed in WO 03/018579, WO 01/46151, WO 02/074726 and WO 02/098878). Such additional compounds also include
30 cholesterol-lowering drugs such as the statins, e.g. simvastatin. Such additional compounds similarly include compounds known to modify the production or processing of A β in the brain ("amyloid modifiers"), such as compounds which inhibit

the secretion of A β (including γ -secretase inhibitors, β -secretase inhibitors, and GSK-3 α inhibitors), compounds which inhibit the aggregation of A β , and antibodies which selectively bind to A β .

In this embodiment of the invention, the amyloid modifier may be a compound which inhibits the secretion of A β , for example an inhibitor of γ -secretase (such as those disclosed in WO 01/53255, WO 01/66564, WO 01/70677, WO 01/90084, WO 01/77144, WO 02/30912, WO 02/36555, WO 02/081435, WO 02/081433, WO 03/018543, WO 03/013506, WO 03/013527 and WO 03/014075), or a β -secretase inhibitor (such as those disclosed in WO 03/037325, WO 03/030886, WO 03/006013, WO 03/006021, WO 03/006423, WO 03/006453, WO 02/002122, WO 01/70672, WO 02/02505, WO 02/02506, WO 02/02512, WO 02/02520, WO 02/098849 and WO 02/100820), or any other compound which inhibits the formation or release of A β , including those disclosed in WO 98/28268, WO 02/47671, WO 99/67221, WO 01/34639, WO 01/34571, WO 00/07995, WO 00/38618, WO 01/92235, WO 01/77086, WO 01/74784, WO 01/74796, WO 01/74783, WO 01/60826, WO 01/19797, WO 01/27108, WO 01/27091, WO 00/50391, WO 02/057252, US 2002/0025955 and US2002/0022621, and also including GSK-3 inhibitors, particularly GSK-3 α inhibitors, such as lithium, as disclosed in Phiel et al, *Nature*, **423** (2003), 435-9.

Within this embodiment, the amyloid modifier is advantageously a γ -secretase inhibitor, preferred examples of which include a compound of formula XI:

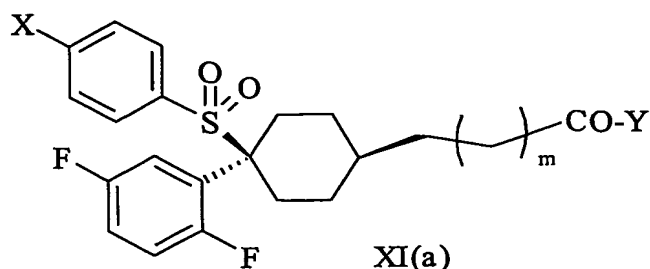


XI

wherein m, Z, R^{1b}, R^{1c}, Ar¹ and Ar² are as defined in WO 03/018543;

or a pharmaceutically acceptable salt thereof.

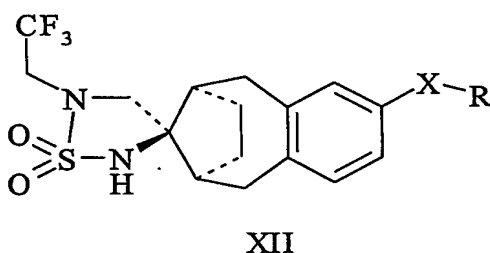
Such compounds may be prepared as described in WO 03/018543. Preferred examples include those defined by formula XIa:



and the pharmaceutically acceptable salts thereof, wherein m is 0 or 1, X is Cl or CF_3 , and Y is OH, $OC_{1-6}alkyl$, NH_2 or $NHC_{1-6}alkyl$. Particular examples include those in which m is 1 and Y is OH (or the sodium salts thereof), and those in which m is 0 and

5 Y is NH_2 or $NHC_{1-6}alkyl$.

Another preferred class of γ -secretase inhibitors for use in this embodiment of the invention is that defined by formula XII:



wherein X and R are as defined in WO 03/093252;

10 or a pharmaceutically acceptable salt thereof.

X is very aptly 5-substituted-thiazol-2-yl, 5-substituted-4-methylthiazol-2-yl, 5-substituted-1-methylpyrazol-3-yl, 1-substituted-imidazol-4-yl or 1-substituted-1,2,4-triazol-3-yl. Preferably, R represents optionally-substituted phenyl or heteroaryl such as phenyl, monohalophenyl, dihalophenyl, trihalophenyl, cyanophenyl, methylphenyl,

15 methoxyphenyl, trifluoromethylphenyl, trifluoromethoxyphenyl, pyridyl, monohalopyridyl and trifluoromethylpyridyl, wherein "halo" refers to fluoro or chloro. Particularly preferred identities of $R-X$ - include 5-(4-fluorophenyl)-1-methylpyrazol-3-yl, 5-(4-chlorophenyl)-1-methylpyrazol-3-yl and 1-(4-fluorophenyl)imidazol-4-yl. Such compounds may be prepared by methods disclosed in WO 03/093252.

20 Further preferred classes of γ -secretase inhibitors include those disclosed in WO 03/093264, WO 03/093251, WO 03/093253, WO 2004/039370, WO 2004/39800 and WO 2004/031139.

Alternatively, the amyloid modifier may be a compound which inhibits the aggregation of A β . Suitable examples include chelating agents such as clioquinol (Gouras and Beal, *Neuron*, **30** (2001), 641-2) and the compounds disclosed in WO 99/16741, in particular that known as DP-109 (Kalendarev et al, *J. Pharm. Biomed. Anal.*, **24** (2001), 967-75). Other inhibitors of A β aggregation suitable for use in the invention include the compounds disclosed in WO 96/28471, WO 98/08868 and WO 00/052048, including the compound known as ApanTM (Praecis); WO 00/064420, WO 03/017994, WO 99/59571 and the compound known as AlzhemedTM (Neurochem); WO 00/149281 and the compositions known as PTI-777 and PTI-00703 (ProteoTech); WO 96/39834, WO 01/83425, WO 01/55093, WO 00/76988, WO 00/76987, WO 00/76969, WO 00/76489, WO 97/26919, WO 97/16194, and WO 97/16191.

Alternatively, the amyloid modifier may be an antibody which binds selectively to A β . Said antibody may be polyclonal or monoclonal, but is preferably monoclonal, and is preferably human or humanized. Preferably, the antibody is capable of sequestering soluble A β from biological fluids, as described in WO 03/016466, WO 03/016467, WO 03/015691 and WO 01/62801. Suitable antibodies include humanized antibody 266 (described in WO 01/62801) and the modified version thereof described in WO 03/016466.

As used herein, the expression "in combination with" requires that therapeutically effective amounts of both the compound of Formula I and the additional compound are administered to the subject, but places no restriction on the manner in which this is achieved. Thus, the two species may be combined in a single dosage form for simultaneous administration to the subject, or may be provided in separate dosage forms for simultaneous or sequential administration to the subject. Sequential administration may be close in time or remote in time, e.g. one species administered in the morning and the other in the evening. The separate species may be administered at the same frequency or at different frequencies, e.g. one species once a day and the other two or more times a day. The separate species may be administered by the same route or by different routes, e.g. one species orally and the other parenterally, although oral administration of both species is preferred, where possible. When the additional compound is an antibody, it will typically be administered parenterally and separately from the compound of Formula I.

In a further aspect, the invention provides a pharmaceutical composition comprising, in a pharmaceutically acceptable carrier, a compound of formula I or a pharmaceutically acceptable salt thereof and a compound of formula XI(a) or a pharmaceutically acceptable salt thereof. Preferably, the pharmaceutical composition
5 is in a unit dose form suitable for oral administration, such as a tablet or a capsule.

EXAMPLES

The ability of the compounds of Formula I to selectively inhibit production of A β (1-
10 42) was determined using the following assay:

Cell-based γ -Secretase Assay

Human SH-SY5Y neuroblastoma cells overexpressing the direct γ -secretase substrate SPA4CT were induced with sodium butyrate (10 mM) for 4 hours prior to
15 plating. Cells were plated at 35,000 cells/well/100 μ l in 96-well plates in phenol red-free MEM/10% FBS, 50 mM HEPES, 1% Glutamine and incubated for 2 hrs at 37 °C, 5% CO₂.

Compounds for testing were diluted into Me₂SO to give a ten point dose-response curve. Typically 10 μ l of these diluted compounds in Me₂SO were further
20 diluted into 182 μ l dilution buffer (phenol red-free MEM/10% FBS, 50 mM HEPES, 1% Glutamine) and 10 μ l of each dilution was added to the cells in 96-well plates (yielding a final Me₂SO concentration of 0.5%). Appropriate vehicle and inhibitor controls were used to determine the window of the assay.

After incubation overnight at 37 °C, 5%CO₂, 10 μ l and 50 μ l media were
25 transferred into a fresh Costar round-bottom 96-well plate for detection of A β (40) and A β (42) peptides, respectively. 40 μ l Origen buffer (PBS, 2% BSA, 0.2% Tween-20) was added to the A β (40) wells followed by the addition of 25 μ l the respective antibody premixes to the wells:

A β (40) premix: 1 μ g/ml ruthenylated G2-10 antibody, 4 μ g/ml
30 biotinylated 4G8 antibody diluted in Origen buffer

A β (42) premix: 0.5 μ g/ml ruthenylated G2-11 antibody, 4 μ g/ml
biotinylated 4G8 antibody diluted in Origen buffer

(Biotinylated 4G8 antibody supplied by Signet Pathology Ltd; G2-10 and G2-
5 11 antibodies supplied by Chemicon)

After overnight incubation of the assay plates on a shaker at 4 °C, the Origen
M8 Analyser (Igen Inc.) was calibrated according to the manufacturer's instructions.
25 μ l of streptavidin magnetic bead (Dyna) premix (400 μ g/ml streptavidin beads/ml
in Origen buffer) was added to the assay plates and incubated on a shaker for 15
10 minutes. 150 μ l Origen buffer was added to each well and the plates were read on the
Origen M8 Analyser according to the manufacturer's instructions.

Cell viability was measured in the corresponding cells after removal of the
media for the A β assays by a colorimetric cell proliferation assay (CellTiter 96TM AQ
assay, Promega) utilizing the bio-reduction of MTS (Owen's reagent) to formazan
15 according to the manufacturer's instructions. Briefly, 5 μ l of 10x MTS/PES was added
to the remaining 50 μ l of media before returning to the incubator. The optical density
was read at 495 nm after ~4 hours.

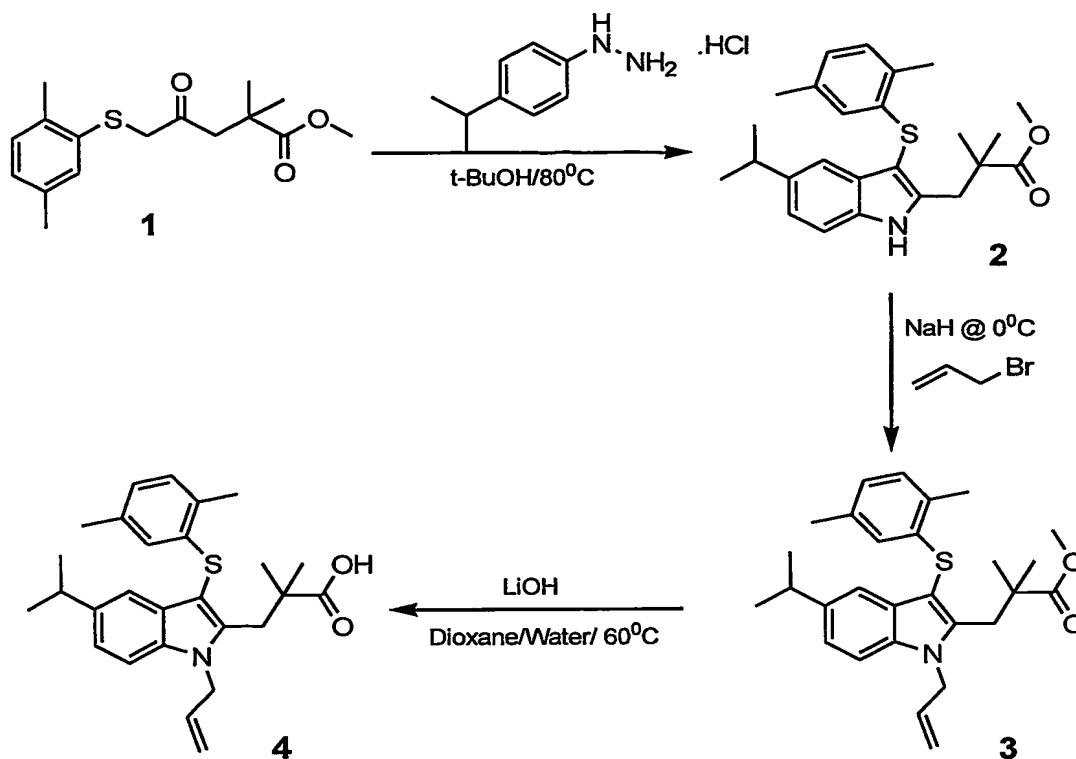
LD₅₀ and IC₅₀ values for inhibition of A β (40) and A β (42) were calculated by
nonlinear regression fit analysis using the appropriate software (eg. Excel fit). The
20 total signal and the background were defined by the corresponding Me₂SO and
inhibitor controls.

The compounds listed in Tables 1 above all gave IC₅₀ values for A β (1-42) inhibition
that were at least 2-fold lower than the corresponding IC₅₀ values for A β (1-40)
25 inhibition, typically at least 5-fold lower, and in the preferred cases at least 50-fold
lower.

All compounds were prepared by the methods disclosed in US 5,081,138; and the
following provides a representative example:-

30

Scheme 1



Methyl 3-{3-[(2,5-dimethylphenyl)thio]-5-isopropyl-1H-indol-2-yl}-2,2-dimethylpropanoate (2)

- 5 A mixture of methyl 5-[(2,5-dimethylphenyl)thio]-2,2-dimethyl-4-oxopentanoate (1) (8.0g, 27.2mmol) [prepared from 5-bromo-2,2-dimethyl-4-oxopentanoate and 2,5-dimethylthiophenol using the method of US 5081138] and (4-isopropylphenyl)hydrazine hydrochloride (5.0g, 26.8mmol) in tert-butanol (50ml) was refluxed for 3hrs. Reaction mixture was cooled to ambient temperature and
- 10 concentrated in vacuo. The residue was diluted with ethyl acetate (100ml) and sequentially washed with water ($1 \times 100\text{ml}$), hydrochloric acid (2N, 100ml) and brine (100ml). The organic extract was dried over MgSO_4 , concentrated in vacuo, and purified by flash chromatography eluting with 2% ethyl acetate:hexane to afford methyl 3-{3-[(2,5-dimethylphenyl)thio]-5-isopropyl-1H-indol-2-yl}-2,2-
- 15 dimethylpropanoate (2) as a off white solid (4.1g, 37%) ^1H NMR δ (ppm) (400MHz, CDCl_3): 9.11 (1 H, s), 7.32 (2 H, m), 7.10 (1 H, dd, $J = 1.5, 8.5$ Hz), 7.01 (1 H, d, $J = 7.5$ Hz), 6.76 (1 H, d, $J = 7.5$ Hz), 6.45 (1 H, s), 3.73 (3 H, s), 3.14 (2 H, s), 3.00-2.90 (1 H, m), 2.46 (3 H, s), 2.03 (3 H, s), 1.20-1.27 (12 H, m).

Methyl 3-{1-allyl-3-[(2,5-dimethylphenyl)thio]-5-isopropyl-1H-indol-2-yl}-2,2-dimethylpropanoate (3)

Sodium hydride (5mg, 0.22mmol) was added in to an ice cold solution of methyl 3-{3-[(2,5-dimethylphenyl)thio]-5-isopropyl-1H-indol-2-yl}-2,2-dimethylpropanoate (2) (60mg, 0.15mmol.) in DMF (3ml) and the resultant mixture stirred for 30min at 0°C. Then a solution of allyl bromide (26.6mg, 0.22mmol) in DMF (1ml) was added slowly and stirring was continued at 0°C for 30min and then at ambient temperature for 18hrs. The reaction mixture was diluted with water (50ml) and extracted with DCM (3×50ml). The organic extracts were washed with brine (1×100ml), dried over MgSO₄ and concentrated in vacuo. The residue was purified by flash chromatography eluting with 2% ethylacetate:hexane to afford methyl 3-{1-allyl-3-[(2,5-dimethylphenyl)thio]-5-isopropyl-1H-indol-2-yl}-2,2-dimethylpropanoate (3) (53mg, 80%). ¹H NMR δ (ppm) (360MHz, CDCl₃): 7.35 (1 H, s), 7.24 (1 H, m), 7.11 (1H, m), 7.00 (1 H, d, J = 7.5 Hz), 6.75 (1 H, d, J = 7.5 Hz), 6.36 (1 H, s), 5.94-5.84 (1 H, m), 5.12 (1 H, d, J = 10.5 Hz), 4.81-4.73 (3 H, m), 3.67 (3 H, s), 3.18 (2 H, s), 3.00-2.90 (1 H, m), 2.44 (3 H, s), 2.01 (3 H, s), 1.28-1.20 (12 H, m),

3-{1-allyl-3-[(2,5-dimethylphenyl)thio]-5-isopropyl-1H-indol-2-yl}-2,2-dimethylpropanoic acid (4)

A solution of lithium hydroxide (28mg, 1.2mmol) in water (1ml) was added into a solution methyl 3-{1-allyl-3-[(2,5-dimethylphenyl)thio]-5-isopropyl-1H-indol-2-yl}-2,2-dimethylpropanoate (3) (53mg, 0.12mmol) in dioxane (2ml) and stirred at 60°C for 18hrs. The reaction mixture was diluted with hydrochloric acid (2N, 50ml) and extracted with ethyl acetate (2×50ml). The organic extract was washed with brine (1×50ml), dried over MgSO₄ and concentrated in vacuo, to afford 3-{1-allyl-3-[(2,5-dimethylphenyl)thio]-5-isopropyl-1H-indol-2-yl}-2,2-dimethylpropanoic acid (41mg, 78%) ¹H NMR δ (ppm) (360MHz, CDCl₃): 7.36 (1 H, s), 7.25 (1H, m), 7.12 (1 H, dd, J = 1.5, 8.5 Hz), 7.00 (1 H, d, J = 7.5 Hz), 6.75 (1 H, d, J = 7.5 Hz), 6.37 (1 H, s), 5.94-5.86 (1 H, m), 5.12 (1 H, d, J = 10.5 Hz), 4.85 (2 H, m), 4.77 (1 H, d, J = 17.0 Hz), 3.22 (2 H, s), 3.01-2.91 (1 H, m), 2.44 (3 H, s), 2.00 (3 H, s), 1.23-1.27 (12 H, m).